

THE CLAIMS

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1. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with a gas-phase reactive halide composition to remove the residue.

2. The method according to claim 1, wherein the reactive halide composition comprises XeF_2 .

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3. The method according to claim 1, wherein the reactive halide composition is selected from the group consisting of SF_6 , SiF_4 , and Si_2F_6 .

4. The method according to claim 1, wherein the reactive halide composition is selected from the group consisting of SiF_2 and SiF_3 radicals.

2/ The method according to claim 1, wherein the contacting is carried out at a temperature from about $-50^\circ C$ to $200^\circ C$.

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6. The method according to claim 1, wherein the microelectronic device structure is disposed in a chamber, further comprising: evacuating the chamber, filling the chamber with a cleaning gas comprising the reactive halide composition, and retaining the reactive

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halide composition in the chamber to react with the residue, to effect removal of the noble metal residue from the microelectronic device structure.

7. The method according to claim 6, wherein the pressure of the chamber upon evacuation is less than or equal to 50 mTorr, the cleaning gas is at a pressure from about 50 mTorr to about 2 Torr, and the reaction time for each fill of cleaning gas in the chamber is from about 10 seconds to 10 minutes.

5 8. The method according to claim 1, wherein the microelectronic device structure is disposed in a chamber, and a cleaning gas comprising the reactive halide composition is continuously flowed through the chamber to effect the removal of the noble metal residue from the microelectronic device structure.

6 9. The method according to claim *8*,⁵ wherein the reactive halide composition is at a vapor pressure from about 50 mTorr to about 2 Torr, and the cleaning gas through the chamber has a flow rate from about 1 standard cubic centimeter per minute to 10 standard liters per minute.

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10. The method according to claim 1, wherein the gas-phase reactive halide composition comprises XeF_2 and the reactive halide composition comprising XeF_2 is generated by an inherent vapor pressure of XeF_2 .

11. The method according to claim 1, wherein the gas-phase reactive halide

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composition comprises XeF₂ and the reactive halide composition comprising XeF₂ is generated by sublimation of solid crystalline XeF₂.

12. The method according to claim 1, wherein the gas-phase reactive halide composition is selected from the group consisting of SiF₂ and SiF₃ radicals and the reactive halide composition is generated by reaction of XeF₂ with silicon.

13. The method according to claim 1, wherein the gas-phase reactive halide composition is selected from the group consisting of SiF₂ and SiF₃ radicals and the reactive halide composition is generated by passing SiF₄ through an energetic dissociation source.

14. The method according to claim 13, wherein the energetic dissociation source is selected from the group consisting of a plasma source, an ion source, an ultra violet source and a laser source.

q 15. The method according to claim 1, wherein the noble metal residue comprises platinum.

16. The method according to claim 1, wherein the noble metal residue comprises palladium.

11. The method according to claim 1, wherein the noble metal residue comprises iridium.

12. The method according to claim 1, wherein the noble metal residue comprises rhodium.

19. The method according to claim 1, wherein the noble metal residue comprises iridium and a cleaning gas comprising the reactive halide composition XeF_2 .

20. The method according to claim 19, further comprising, contacting the microelectronic device structure with a cleaning enhancement agent to assist in volatilizing and removing the noble metal residue on the microelectronic device structure.

21. The method according to claim 20, wherein the cleaning enhancement agent is selected from the group consisting of Lewis-base adducts and electron back-bonding species.

22. The method according to claim 20, wherein the cleaning enhancement agent is selected from the group consisting of carbon monoxide, trifluorophosphine, and trialkylphosphines.

23. The method according to claim 22 wherein the cleaning enhancement agent

20 34. The method according to claim 1, wherein the microelectronic device structure comprises a capacitor.

24 35. The method according to claim 34, wherein the capacitor is selected from the group consisting of a Type 1-capacitor structure, a Type 2-capacitor structure and a Type 3-capacitor structure.

25 36. The method according to claim 1, wherein the contacting of the microelectronic device structure with the reactive halide composition is conducted after reactive ion etching of a noble metal electrode film on the microelectronic device structure.

26 37. The method according to claim 1, wherein the contacting of the microelectronic device structure with the reactive halide composition is conducted after chemical mechanical polishing of a noble metal electrode film on the microelectronic device structure.

27 38. The method according to claim 1, wherein the microelectronic device structure comprises a patterned bottom electrode of a capacitor structure, and the contacting is carried out after patterning of the bottom electrode.

~~28~~ 39. The method according to claim 1, wherein the microelectronic device structure comprises a Type 2 capacitor structure, and the contacting comprises removing sidewall residue and ears of the capacitor structure.

~~29~~ 40. The method according to claim 1, wherein the microelectronic device structure comprises a Type 3 capacitor structure, and the contacting is carried out to remove residue from a chemical mechanical polishing of the Type 3-capacitor structure.

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41. A method for removing from a microelectronic device structure a noble metal residue including at least one metal selected from the group consisting of platinum, palladium, iridium and rhodium, the method comprising contacting the microelectronic device structure with gas-phase XeF_2 to at least partially remove the noble metal residue.

31 ~~42~~ The method according to claim ~~41~~ ³⁹, wherein the contacting is carried out at a temperature from about $-50^\circ C$ to about $200^\circ C$.

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43. The method according to claim 41 wherein elemental silicon is present with the gas-phase XeF_2 in said contacting.

44. The method according to claim 41, wherein the microelectronic device structure is disposed in a chamber, further comprising evacuating the chamber, filling the chamber with a cleaning gas comprising XeF_2 , and retaining the cleaning in the chamber to react

Sub 46 [with the residue, to effect the removal of the noble metal residue from the microelectronic device structure.

34 45. The method according to claim *44*, wherein the pressure of the chamber upon evacuation is less than or equal to 50 mTorr, the cleaning gas is at a pressure from about 50 mTorr to about 2 Torr, and the reaction time for each fill of cleaning gas is from about 10 seconds to about 10 min.

35 46. The method according to claim *44*, wherein elemental silicon is present in the chamber.

Sub 47 [47. The method according to claim *41*, wherein the microelectronic device structure is disposed in a chamber, and the cleaning gas comprising a gas phase reactive halide composition selected from the group consisting of SF₆, SiF₄ and Si₂F₆, is continually flowed through the chamber, in combination with an energetic dissociation source.

37 48. The method according to claim *41*, wherein the energetic dissociation source is selected from the group consisting of a plasma source, an ion source, an ultra violet source and a laser source.

Sub 49 50. The method according to claim *46*, wherein the gas phase reactive halide composition is selected from the group of radicals consisting of SiF₂ and SiF₃.

comprises an iridium halide species selected from the group consisting of $\text{Ir}(\text{X})_1$, $\text{Ir}(\text{X})_3$, $\text{Ir}(\text{X})_4$ and $\text{Ir}(\text{X})_6$, wherein X represents the halide of the reactive halide composition.

24. The method according to claim 19, wherein the cleaning gas further comprising a gas phase reactive halide species selected from the group consisting of SF_6 , SiF_4 , Si_2F_6 and SiF_2 and SiF_3 radicals and the microelectronic device structure, is further contacted with a cleaning enhancement agent.

25. The method according to claim 24, wherein the cleaning enhancement agent is selected from the group consisting of Lewis-base adducts and electron back-bonding species.

26. The method according to claim 24, wherein the cleaning enhancement agent is selected from the group consisting of carbon monoxide, trifluorophosphine, and trialkylphosphines.

27. The method according to claim 24 wherein the cleaning enhancement agent comprises an iridium halide species from the group consisting of $\text{Ir}(\text{X})_1$, $\text{Ir}(\text{X})_3$, $\text{Ir}(\text{X})_4$ and $\text{Ir}(\text{X})_6$, wherein X represents the halide of the reactive halide composition.

28. The method according to claim 1, wherein the contacting of the microelectronic device structure with the gas phase reactive halide composition is carried out with a

cleaning enhancement agent and the contacting comprises an enhancement step selected from the group consisting of:

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- (a) providing an inert gas in the cleaning enhancement agent;
- (b) carrying out the contacting in an ion-beam-assisted manner;
- (c) carrying out the contacting in a plasma-assisted manner;
- (d) carrying out the contacting in a photo-assisted manner and
- (e) carrying out the contacting in a laser assisted manner.

29. The method according to claim 1, wherein the noble metal residue comprises iridium, and carbon monoxide is present in the contacting.

30. The method according to claim 1, wherein a hexafluoride compound of the noble metal is present in the contacting.

31. The method according to claim 1, wherein a silicon fluoride compound is present in the contacting.

32. The method according to claim 1, wherein the noble metal residue comprises iridium, and IrF_6 is present in the contacting.

33. The method according to claim 1, wherein a Lewis base ligand is present in said contacting, to enhance the removal of the noble metal residue.

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51. The method according to claim 47, wherein the gas phase reactive halide composition is selected from the group of radicals consisting of SiF₂ and SiF₃.

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